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(71) Applicant(s)
Alstec Limited
(Incorporated in the United Kingdom)
Cambridge Road, Whetstone, LEICESTER, LE8 6LH, United Kingdom

(72) Inventor(s)
Melvyn Cavanagh
Dominique Lefebvre

(74) Agent and/or Address for Service
Barker Brettell
138 Hagley Road, Edgbaston, BIRMINGHAM, B16 9PW, United Kingdom

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(54) Abstract Title
Monitoring electrical machines

(57) A method of generating a precursor signal indicative of the onset of failure of the insulation in a machine, such as that around a stator in a generator 3, comprises the steps of obtaining at least one measurement dataset of partial discharge data from the machine, the data being representative of the magnitude of and number of partial discharges from the machine over at least one substantially complete alternating cycle; generating from the measured data a taxonome a statistical representation of the number N of partial discharges in the dataset as classified by their associated magnitude Q; comparing the taxonome to at least one reference taxonome previously obtained from the machine; and generating from the result of the comparison an indicator signal indicative of the onset of breakdown of the insulation. Sensors 8 may also measure power, speed, temperatures and vibration. Signal processing apparatus includes an A-D converter 10 and memory 11 coupled to a remote computer 15 connected to a display 16a and alarm 16b.

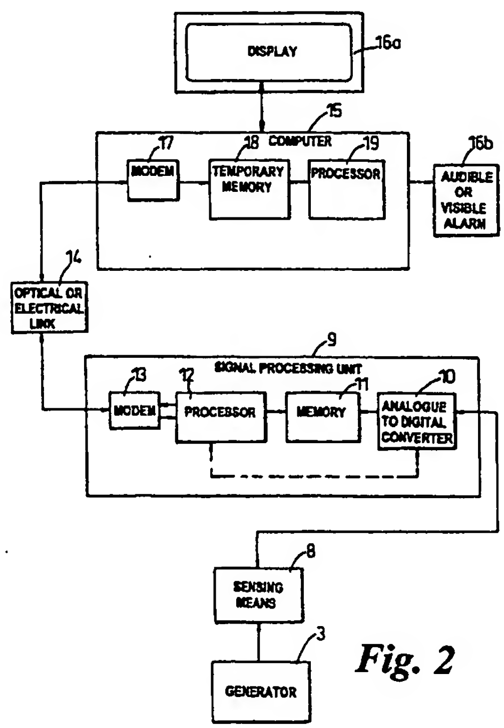

Fig. 2

GB 2 368 733 A

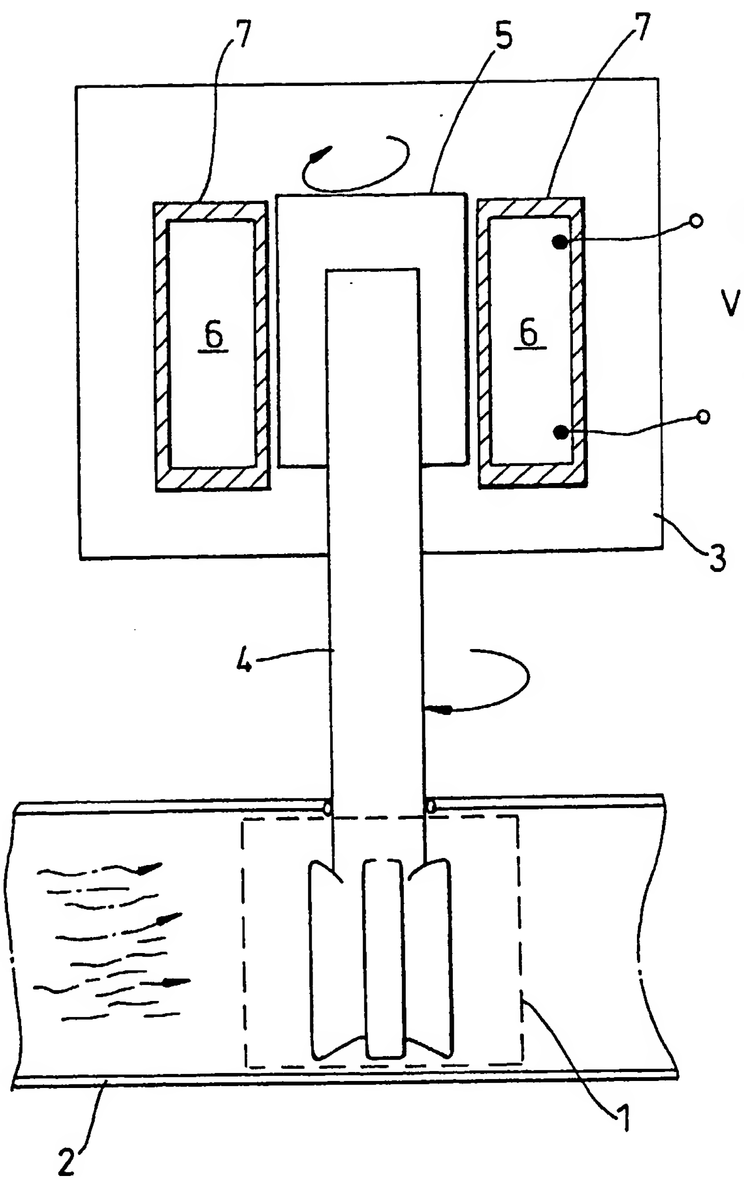

Fig. 1

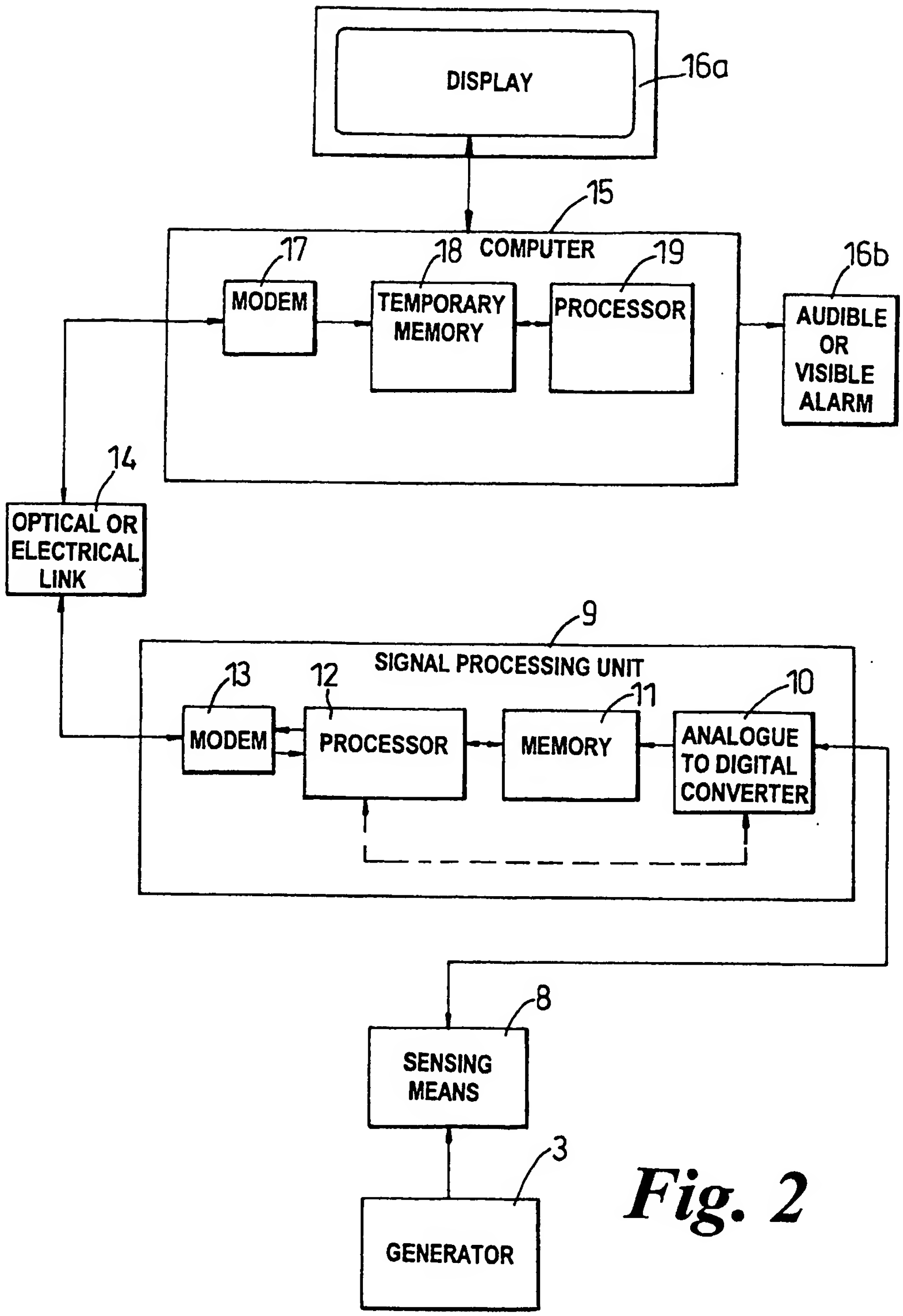
DISPLAY
16a
15
COMPUTER
17
MODEM
18
TEMPORARY MEMORY
19
PROCESSOR
16b
AUDIBLE OR VISIBLE ALARM
14
OPTICAL OR ELECTRICAL LINK
9
SIGNAL PROCESSING UNIT
13
MODEM
12
PROCESSOR
11
MEMORY
10
ANALOGUE TO DIGITAL CONVERTER
8
SENSING MEANS
3
GENERATOR

Fig. 2

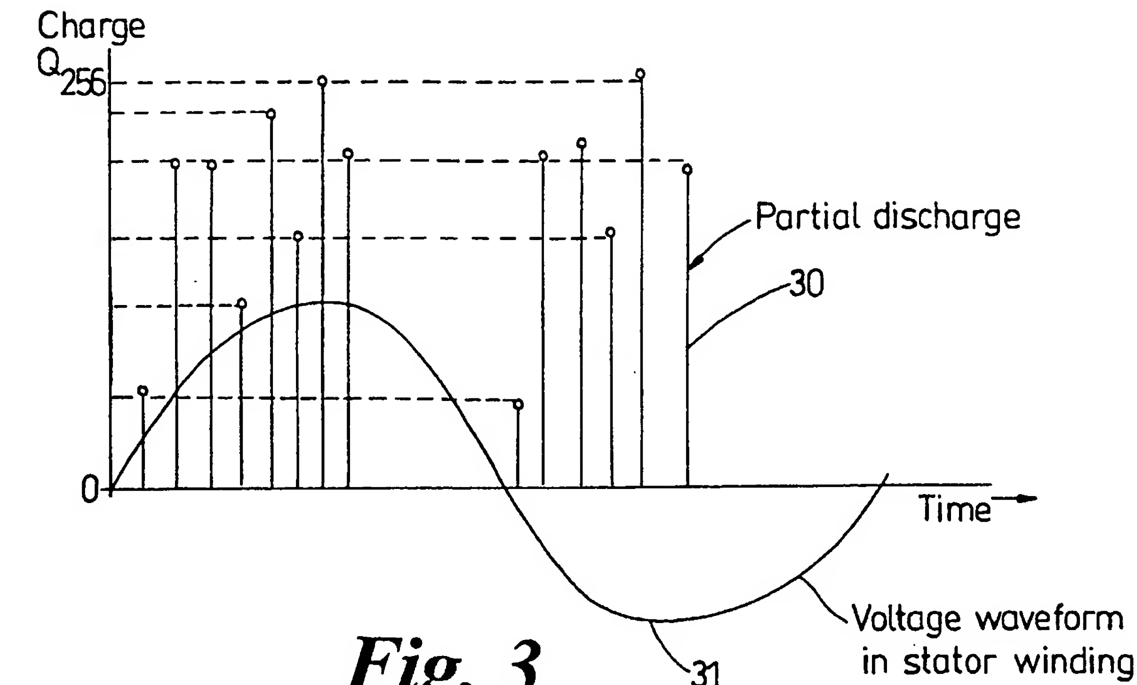
Charge
Q
256
0
Partial discharge
30
Time
Voltage waveform
in stator winding
31

Fig. 3

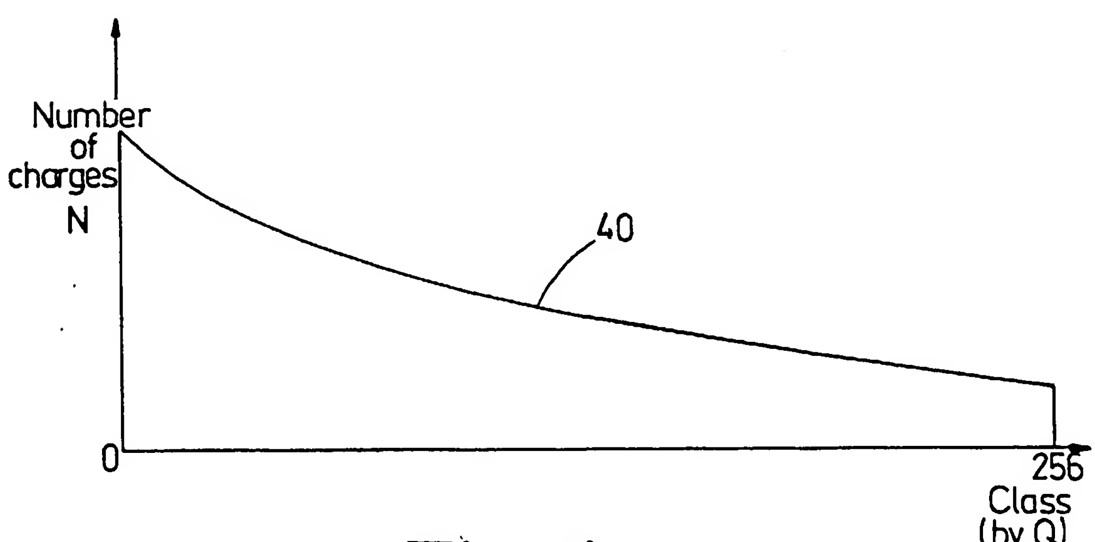
Number
of
charges
N
40
0
256
Class
(by Q)

Fig. 4

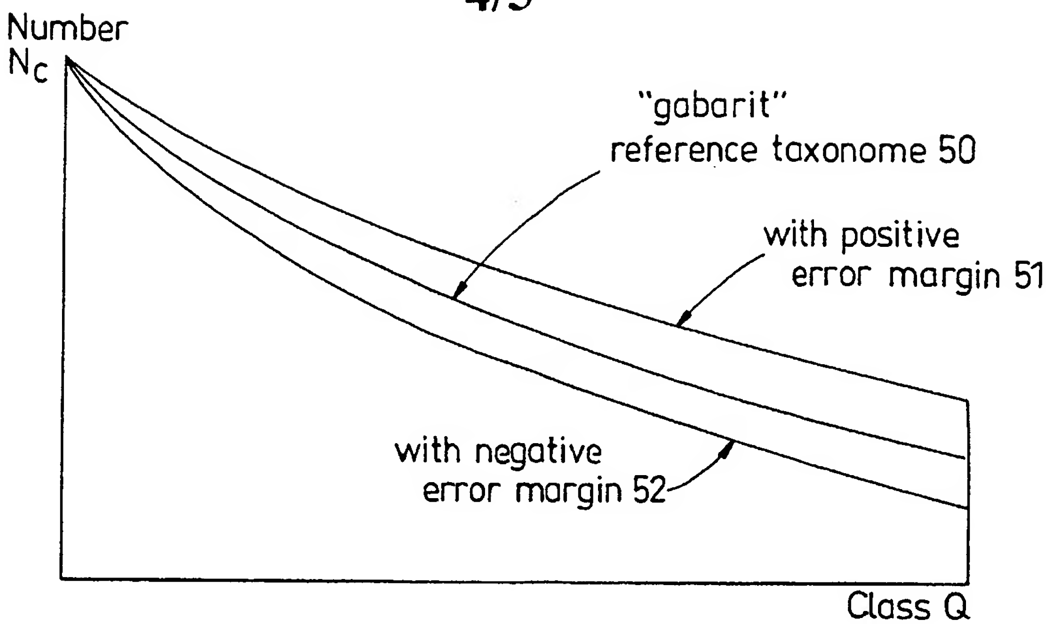
Number
N_c
"gabarit"
reference taxonome 50
with positive
error margin 51
with negative
error margin 52
Class Q

Fig. 5

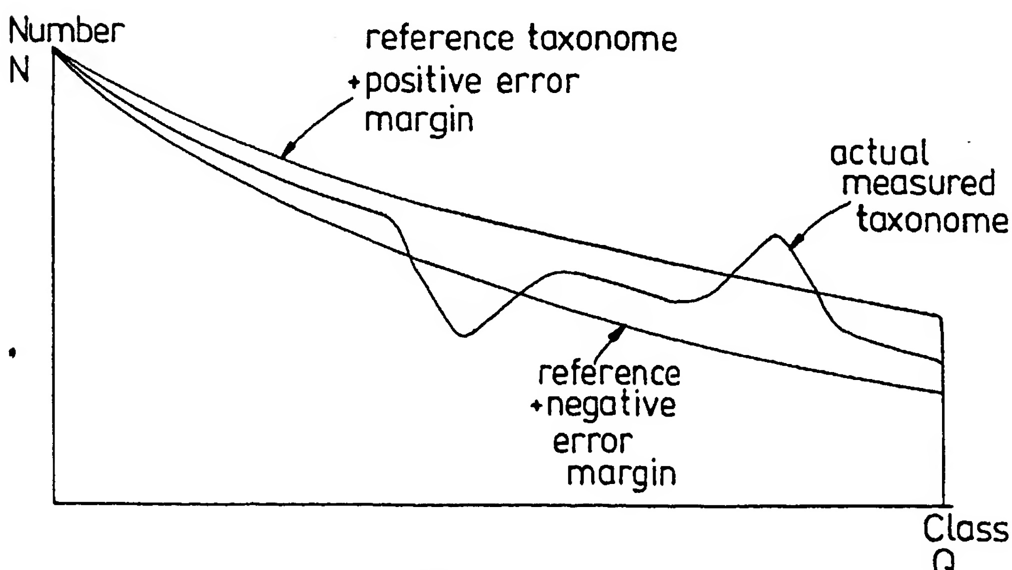
Number
N
reference taxonome
+positive error
margin
actual
measured
taxonome
reference
+negative
error
margin
Class
Q

Fig. 6

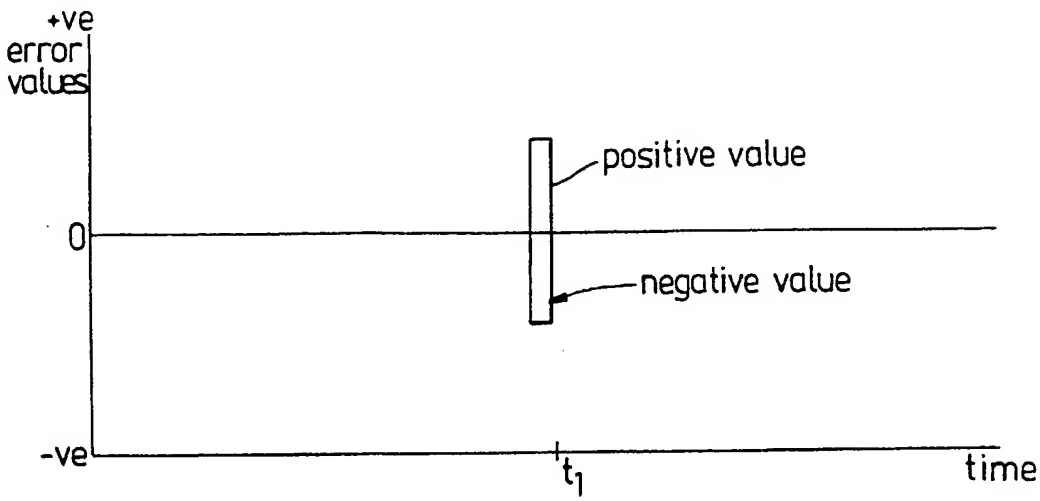
+ve
error
values
positive value
0
negative value
-ve
t_1
time

Fig. 7

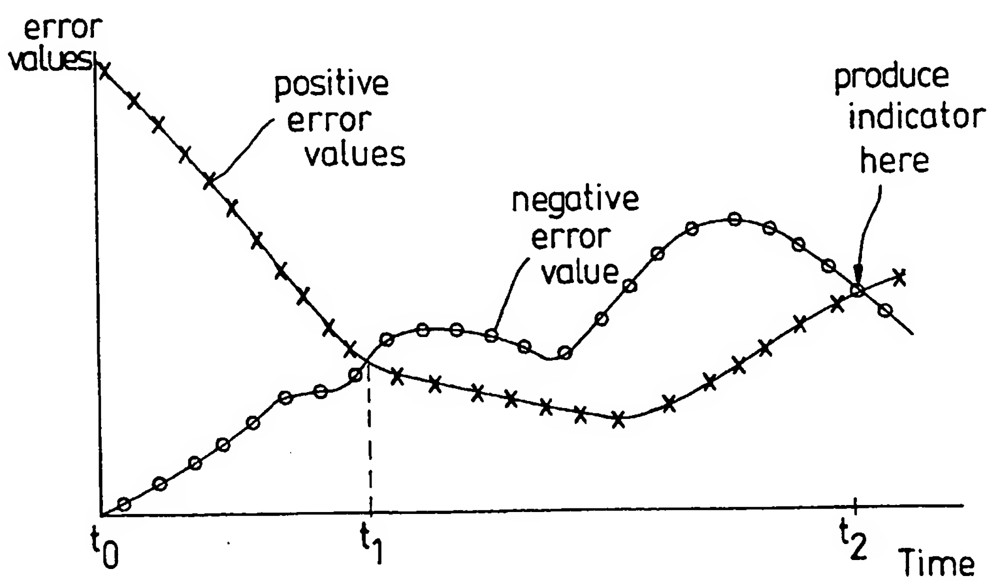
error
values
positive
error
values
negative
error
value
produce
indicator
here
t_0
t_1
t_2
Time

Fig. 8

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IMPROVEMENTS IN MONITORING APPARATUS

This invention relates to improvements in monitoring apparatus, and in particular to a monitoring apparatus and a method for monitoring the degradation of electrical insulation, such as that used in electrical machines.

The construction of large rotating electrical machines commenced at the beginning of the twentieth century. Over the years many types of failure have been identified and modifications to machines have been made in an attempt to prevent them occurring in future. From an examination of an analysis of these failures it is now recognised that a main source of failure is the degradation of the electrical insulation that is provided around the stator windings of these machines.

The insulation must fulfil several functions. It must electrically separate the conductors of the stator windings both from each other and from the magnetic core of the machine. It must equally have a high mechanical resistance, support high temperatures, conduct away heat and adhere to the conductors.

Unfortunately, no material exists which perfectly satisfies all of these requirements and even the most expensive materials will degrade over time and eventually fail. The material used must therefore be regularly inspected requiring the machine to be stopped and the stator inspected. The insulation material is then replaced if degraded.

Because stopping the machine is undesirable and potentially expensive the ability to predict when an electrical machine is about to fail is very important and a reliable detection method can enable predictive maintenance to be carried out. An example of a system in which

predictive maintenance can provide a considerable reduction in downtime is the use of turbine driven generators in the electrical power supply industry. These machines are often required to supply a boost of power to the distribution network. At such times a sudden run up of the turbine followed by the connection of the generator to its electrical load places large mechanical strain on the stator windings that can lead to premature ageing. Predictive maintenance enables the optimum time for the machine to be inspected, or perhaps overhauled, to be estimated. Without predictive maintenance it would be necessary to inspect or overhaul the machine more frequently as a conservative estimate of the machines life would be used. To leave the servicing too late and allow a failure to occur would be prohibitively expensive and possibly hazardous.

Predictive maintenance of machines based upon the mechanical vibrations of the machine is well advanced in the art. Although vibrations do accelerate the ageing process, the correlation between vibration in the machine and the degradation of the insulation is not always predictable. Until now the problem of accurate predictive maintenance of the insulation of the electrical machine has therefore remained largely unsolved.

One method that has been proposed to monitor the condition of the stator insulation is based upon monitoring partial discharges within the machine. Partial discharges are electrical pulses or discharges involving the flow of electrons and ions when a small volume of gas breaks down within voids in the insulation. As the material degrades more voids appear and the size of the voids may vary. The number of these partial discharges and their magnitude in a given sampling period will vary over time as the insulation degrades.

Although several attempts to use the partial discharge measurements to predict the condition of the insulation have been made there does not at present exist an apparatus or method of using the information reliably to predict when the machine is about to fail.

In accordance with a first aspect the invention provides a method of generating a precursor signal indicative of the onset of failure of the insulation in an electrical machine or component, the method comprising the steps of;

obtaining at least one measurement dataset of partial discharge data from the machine, the data being representative of the magnitude of and number of partial discharges from the machine over at least one substantially complete alternating cycle;

generating a taxonome from the measured data, the taxonome comprising a statistical representation of the number N of partial discharges in the dataset as classified by their associated magnitude measurement Q;

comparing the taxonome to at least one reference taxonome previously obtained from the machine;

and generating from the result of the comparison an indicator signal indicative of the onset of breakdown of the insulation.

The invention therefore provides a method of producing an indicator that is a precursor to failure of the insulation in a machine or component from an analysis of partial discharge data by the production and comparison of taxonomes. It can be used to monitor stator insulation in rotating machines or electrical components such as insulated electrical cable for high voltage.

It is preferred that the measured data forming a dataset is obtained over a single 360 degrees electrical alternating cycle of the machine insulation

voltage, it could be obtained from a multiple of full cycles. It may, for example be a voltage cycle in a stator winding of the machine.

The method may further comprise an initial step of generating the reference taxonome by obtaining at least one dataset of partial discharge data from the machine before degradation has significantly commenced. This dataset may be obtained when the machine is first installed, or at any time when it is known that relatively fresh un-degraded stator insulation is present in the machine.

The reference taxonome may be generated by obtaining several datasets of data, forming a taxonome for the data in each dataset, and taking the mean (or some other statistical average) of the data in the taxonomes.

The or each taxonome obtained from the measured data may be compared to the reference taxonome to produce a positive and a negative error value, the two error values being compared to produce the indicator signal.

The positive error value may be indicative of the number of partial discharges in a given class of the taxonome that exceed the number of partial discharges in the corresponding class of the reference taxonome. The total number of partial discharges that meet this requirement across all classes of the taxonome may be used to form the basis of the positive error value. Of course, only a subset of the total number of classes need be compared if required, i.e. alternate classes.

The negative error value can be similarly derived and may therefore be indicative of the number of partial discharges in a given class of the reference taxonome that exceed the number of partial discharges in the corresponding class of the measured taxonome. It is preferred that the

total number of partial discharges that meet this requirement across all classes of the taxonome form the basis of the negative error value.

The indicator may be produced when the positive error value and negative error value is substantially identical. This will typically occur at the point in time immediately following that at which the negative values have exceeded the positive values. This provides the precursor of machine failure. In practice, during operation of the machine the error values will be equal valued at two points in time, the indicator being produced at the second time that they cross.

To remove noise from the comparison and allow for errors in the data each error value may be produced by only counting the numbers of discharges in each class that exceed (or fall below) the reference by a predetermined error margin. The error margin used may be the same for each class of the taxonome or may differ from class to class. An error margin of 30 percent or more may be used in some cases.

The applicant has found, surprisingly, that in most if not all cases the positive error values produced will initially exceed the number of negative errors. Over time they will then cross so that more negative errors occur than positive errors. They will then cross again as the machine ages and this is used as an indicator that a fault may be about to occur.

The data for each taxonome may be obtained whilst the machine is on-line or alternatively may be obtained whilst the machine is off-line. The data may be obtained as an analogue signal and subsequently digitised, or directly obtained as digital data. The digital values, each representative of the magnitude of a partial discharge may be stored in an electronic memory before producing the taxonome. It will be appreciated that the number of classes in the taxonome will depend on the number of levels

available in producing the digital data. For example, digital data that can take any value in the range 0-255 will allow a maximum of 256 classes to be provided in the taxonome.

Each taxonome may be obtained at a predetermined time interval during operation of the machine. For example, the taxonomes may be obtained at regularly spaced time intervals during the machines operating life until the indicator that failure is imminent is produced.

Alternatively, the data forming each taxonome may be obtained at a time dependent upon the operating regime of the machine. For example, the method may comprise the step of obtaining more datasets when the machine is accelerating than when it is in a steady state. The method therefore provides the capacity for taking into account the operating regime of the machine.

The method may comprise obtaining the data samples to form the taxonomes whenever the machine operating conditions meet one or more predetermined conditions. For example, the method may only obtain the samples whenever the machine is accelerating, e.g. on initial start-up. The method may therefore include a step of measuring the operating parameters of the machine. These parameters may include temperature, power etc.

More than one reference taxonome may be provided corresponding to different operating regimes of the machine. The method may then comprise the steps of monitoring the operating regime of the machine and comparing the taxonomes obtained during a given regime with the respective reference taxonome for that regime.

The method is suitable for the monitoring of any electrical machine in which a conductor, such as a stator winding, protected by electrical insulation is present. This includes heavy-duty generators and motors. It may also find application in other fields in which partial discharges are present during operation of the machine or for high voltage cables and conductors. Indeed, it is envisaged that it will find application in any instance where a conductor is surrounded by an insulating material and partial discharges occur. This includes the monitoring of high voltage cables, stator winding, transformers, generators, circuit breakers etc.

The method may comprise generating the taxonome from the raw data of each dataset locally at the machine. The taxonome may then be transmitted to a remote site for further processing to generate the indicator signal.

According to a second aspect the invention provides a monitoring apparatus for an electrical machine or component, the apparatus comprising:

sensing means located at the machine that is adapted to produce at least one output signal indicative of the amplitude of and number of partial discharges that occur in the machine, such as in a machines stator windings;

signal receiving means that is adapted to receive the output signal from the sensing means;

storage means adapted to store the data contained in the output signal received by the signal receiving means to form a dataset comprising the total number N of partial discharges occurring over at least one substantially complete electrical cycle; and

signal processing means adapted to process the N stored data values to produce a taxonome comprising a statistical representation of the number

Nc of partial discharges in the dataset as classified by their associated magnitude Q.

The signal receiving means may be located proximal to the machine.

The apparatus may further include a data transmission means whereby the taxonome, and optionally the raw data stored in the storage means can be transmitted to a remote supervisory system for further processing. The transmission means may comprise a modem that is connected over an optical link.

The sensing means may further be adapted to produce one or more additional output signals representative of the operating conditions of the machine. These signals may be indicative of one or more of the environmental, thermal, electrical and mechanical states under which the machine is operating.

The apparatus may be adapted to produce taxonomes from the output of the sensing means at times determined by the operating regime of the machine. The apparatus may be adapted to produce more taxonomes for one operating regime than another, for example at acceleration of the machine rather than during steady state operation. The sensors that monitor the operating conditions could enable the apparatus to select when to take the measurements.

The apparatus may therefore include the capacity to automatically take into account the operational regime of the machine that it is monitoring. From knowledge of the operating regime, which can be obtained from the output from the sensing means, the refresh and scanning rate at which the taxonomes are obtained can be controlled and automatically adjusted as required. No interference by a human operator needs to be provided.

The apparatus may be adapted to process the stored data to produce an indicator signal that is a precursor of failure of the stator insulation in the electrical machine. This signal may be produced in accordance with the method of the first aspect of the invention.

The apparatus may comprise at least two processing units. A first processing unit, that may be in the form of a fast data acquisition device, may be provided which is adapted to download the raw data and produce the taxonomes from the raw data. A second processing unit may be provided that is adapted to correlate the taxonomes with the data indicative of the operating conditions of the machine. The second processing unit may function in a supervisory role to control the operation of the first processing unit. The second unit may supervise the first unit in dependence of the operating regime of the machine that is being monitored.

The first processing unit may be provided local to the machine. The second unit may be provided at a remote location. A communication link may be provided between the two units.

If it is required to monitor several machines a single second processing unit may be provided that supervises a number of first processing units. One first processing unit may be provided for each machine.

There will now be described by way of example only one embodiment of the present invention with reference to the accompanying drawings of which:

Figure 1 is a schematic of a typical power generation scheme incorporating an electrical machine;

Figure 2 is a schematic of a monitoring apparatus in accordance with one aspect of the present invention which is adapted to monitor the ageing of the machine insulation;

Figure 3 is a simplified plot of the charge magnitude of the partial discharges measured over time during a full voltage cycle within the stator windings of the machine;

Figure 4 is a two-dimensional illustration of a taxonome obtained by classifying the partial discharges by their amplitude;

Figure 5 is a plot of class against number of partial discharges in that class for a typical reference taxonome or gabarit, and also illustrating both positive and negative modified gabarits obtained by adding an error margin to the gabarit;

Figure 6 is a plot showing a single measured taxonome obtained during operation of the apparatus at time t_1 overlaid with the positive and negative error margins of the gabarit;

Figure 7 is a plot of the error valves calculated for time t_1 and illustrates the number of partial discharges that exceed or fall below the positive and negative error margins of the gabarit respectively using the taxonome of Figure 6 as an example; and

Figure 8 is a plot of many measured negative and positive error values over time illustrating the location of the first and second cross-over points.

Figure 1 shows schematically an electrical machine incorporated into a simple power generation scheme and monitored by apparatus in accordance with a first aspect of the invention.

The generation scheme comprises a turbine 1 that is driven by water flowing along a pipe 2 under the force of gravity from a reservoir (not shown). The turbine 1 is connected to a generator 3 by a drive shaft 4 that passes through the centre of the generator 3 and carries a number of magnetic poles 5. Around the poles 5 the generator 3 is provided with a number of stator windings 6 that are shielded both from each other and from the magnets 5 by a layer of insulating material 7.

In use, the water flowing along the pipe 2 rotates the turbine 3 that in turn causes the magnets 5 to rotate within the windings 6. As the magnetic field moves relative to the windings 6 an electrical current is generated in the windings that produces a voltage output, for example at 50Hz, for supply to an electricity distribution network.

As the machine ages the insulation 7 degrades. The high voltage across the windings produces partial discharges. Each partial discharge can be characterised by both the time at which it occurs and the amount of charge associated with the discharge. The number and types of discharges that occur may be influenced by thermal, mechanical, chemical or other forces acting on the insulation material.

The monitoring apparatus illustrated in Figure 2 of the accompanying drawings monitors these discharges and from the information contained therein produces an indicator representative of the time at which the insulation is likely to fail or about to fail.

The monitoring apparatus comprises of several functional units. A sensing means 8 is provided that consists of sensing devices that monitor the behaviour of the generator as well as the operating conditions. The sensors include a partial discharge monitor that detects partial discharges that occur in the windings.

The sensing devices also obtain measurements of the following parameters that together provide an accurate picture of the operating regime of the machine:

Active power produced by the machine;
Reactive power produced at the machine;
Speed of the turbine;
Stator winding temperature;
Machine cold air temperature;
Machine hot air temperature;
Cooling water temperature;
Stator temperature;
Stator mechanical vibration.

Of course, not all of the above measurements need to be made available in all cases. However, the more data than can be provided the more accurate a picture of the operating regime of the machine that can be produced.

The output signals from the sensing unit 8 are fed to a first signal processing unit 9 located close to the generator. The raw data in the output signals is made available as analogue data. This is digitised, for example to 256 bit accuracy, by an analogue to digital converter 10 before being stored in temporary memory 11 within the signal processing unit. The numerical value of each digitised sample obtained from the partial discharge sensor corresponds to the magnitude of the partial discharge,

i.e. the amount of charge Q in each partial discharge. The local signal processing unit is located close to the generator to ensure that the output signals are not degraded as may occur if they are transmitted over long distances.

The partial discharge monitor does not capture data continuously but only captures data in response to a capture command signal supplied by the local signal processing unit. Whenever a capture command signal is issued the partial discharge monitor 8 captures a dataset of N partial discharge measurements that correspond to a complete set of partial discharges over a full cycle of the voltage in the stator windings, i.e. one positive and one negative half cycle. This dataset is stored in the temporary memory 11.

This process of capturing a dataset is repeated many times over the operating life of the machine. Each time a new dataset is captured it is stored in the memory 11.

Figure 3 illustrates in a simplified manner the occurrence of the partial discharges in a measured dataset. The figure plots the charge Q associated with each discharge against time. As can be seen, most of the partial discharges 30 occur in the first half of each of the positive and negative-going half cycles of the voltage waveform in the stator windings. In practice, many more discharges than are shown occur for a given cycle.

After a dataset is captured by the signal processor unit the data values are processed locally by a processor 12 to produce a taxonome. The taxonome 40 is a statistical representation of the number of partial discharges in the dataset as classified by magnitude.

The taxonome 40 can be represented graphically in two-dimensions as shown in Figure 4 of the accompanying drawings. On the x-axis the

magnitude of the partial discharges (i.e. the charge) is plotted. Each digitised magnitude value along the x-axis represents a class in the taxonome. On the y-axis the number of discharges Nc measured at each magnitude (i.e in each class) is plotted. Within the processor this information can be conveniently stored as a one-dimensional array. In this example the array will comprise 256 entries or classes, each having a numerical value corresponding to the number of partial discharges that fall into that class. The sum of all the numerical values Nc for the classes is equal to the total number of discharges N in the dataset.

As well as generating the taxonome 40 and storing the raw partial discharge data in the memory 11, the signal processing unit also stores the output of all the other sensors. All this data, including the taxonome, is then transmitted using a modem 13 along an optical link 14 to a supervisory computer 15 located remotely from the machine 3. This computer 15 can conveniently be located in a central control room where operators can check the machines operation by monitoring a display 16a associated with the computer 15. The computer is also attached to an audible or visual alarm 16b that can be operated to indicate a fault or the potential onset of a fault at the machine 3.

The computer 15 includes a modem 17 that receives the information transmitted over the link 14 from the signal processing unit 9. Initially the computer 15 stores the received data into an area of temporary memory 18 for further processing. The computer controls the operation of the signal processing unit and so instructs the signal processing unit when datasets are required, i.e. when to issue the capture signal. It also includes a processor 19 that processes the taxonome stored in the memory 18 to provide the indicator of the machines condition. This indicator is used to drive the alarm 16b.

In order to analyse the taxonome obtained from the local signal processing unit 9 the computer 15 utilises a reference taxonome 50, hereinafter referred to as a gabarit, to which the measured taxonomes are compared. The gabarit 50 is stored in the memory 18 of the computer.

The gabarit 50 is produced from several datasets of partial discharge data, each allowing a taxonome to be obtained, obtained during the initial running of the machine. The average of these taxonomes is taken to produce the gabarit 50 that is stored in memory. In practice, several of these gabarits may be stored by the computer-each one corresponding to a different operating regime of the generator 3. For example, a gabarit 50 may be stored which corresponds to the partial discharges that occur during start-up of the machine as it accelerates from a standstill. Another may be stored that corresponds to the partial discharges that occur as the generator is running at a steady speed. A taxonome 40 that is obtained during operation of the machine will then only be compared to the gabarit 50 that corresponds to the regime under which that taxonome is obtained. The outputs from the speed sensors, temperature sensors, flow gauges etc allow this to be achieved automatically without manual intervention being needed by an operator.

Figure 5 illustrates a typical gabarit 50 for a recently commissioned machine. It can also be seen that for each reference gabarit a positive and negative error margin 51, 52 is calculated and stored in the memory 18. The positive error margin is obtained by adding an error margin to the numerical value Nc recorded at each class in the dataset. The negative error margin corresponds to the reference gabarit with an error margin subtracted from each numericalvalue Nc in the dataset.

Having established the reference gabarit and the error margins 51,52, the computer uploads taxonomes 40 from the signal processing unit 9 at many

time intervals over the operating time of the generator which may run for many years. Over this time the insulation degrades which causes a change in the form of the taxonomes that are produced. In practice, taxonomes are generated continuously over the life of the machine, stored and compared with the reference gabarit 50.

The computer 15 is adapted to compare each taxonome 40 obtained during operation of the machine 3 with a corresponding pair of positive and negative error margins 51,52. This is shown graphically in the example of Figure 6 of the accompanying drawings. For a single taxonome obtained at time t_1.

For each class in the taxonome (i.e. each charge value), the computer checks to see if the number Nc of partial discharges in the taxonome at that class exceeds the number Nc of partial discharges in that class in the positive reference gabarit. Figure 7 of the accompanying drawings illustrates the values of Nc obtained for the positive comparison for the taxonome of Figure 6. The total number Npos of partial discharges measured that exceed their corresponding entries in the positive gabarit is stored in the temporary memory. This value defines a positive error value. In the example of Figures 6 and 7, the negative error value and positive error value are equal as the measured taxonome uses the positive error margin as much as the measure taxonome lies below the negative error margin.

The same step is repeated to calculate the number of partial discharges in the taxonome at each class that fall below the corresponding number of discharges at the same class in the negative error margin. This is also shown in Figure 7 of the accompanying drawings. The total number of these discharges Nneg is stored as a negative error value.

Over time, a record complete of the positive and negative error values can be established. The record, when plotted graphically against time, follows a distinctive pattern as shown in Figure 8 of the accompanying drawings. Initially, at time t0 the value of the positive error value Npos is lower than that of the negative error value Nneg. Over time the positive error value increases as the negative error value decreases until they are equal at a time t1. Thereafter the positive error value exceeds the negative error value. At a later still time t2 the negative error value increases as the positive error value starts to fall until they are equal for a second time. It has been found surprisingly that this crossing at time t2 is a reliable indicator of the point in time at which the stator insulation is most likely to fail. At this point the computer 15 raises a flag as a precursor of the imminent failure of the insulation and issues an alarm 16b.

It will, of course, be understood that although a graphical representation of the change in the positive and negative error values may be provided by the computer on the display 16a it is not essential. Of course, it is also not essential that an error flag is raised. A graphical representation of the change in the positive and negative values over time could be provided on a display screen or print-out. An operator may then be left to identify when the two values cross for the second time from the representation. As the time scale for degradation is quite long, and may be several years, a check need then only be made periodically.

For optimum results, the computer 15 is adapted to decide when to obtain the datasets for forming taxonomes at those times where the most reliable or useful information can be obtained. In the example shown, most degradation will occur on start-up of the machine. In this case the computer may instruct the signal processor 9 to obtain many datasets during start-up and less during other operating regimes.

CLAIMS

1. A method of generating a precursor signal indicative of the onset of failure of electrical insulation in an electrical machine or component, the method comprising the steps of;
obtaining at least one measurement dataset of partial discharge data from the machine, the data being representative of the magnitude of and number of partial discharges in the machine over at least one substantially complete electrical cycle;
generating a taxonome from the measured data, the taxonome comprising a statistical representation of the number N of partial discharges in the dataset as classified by their associated magnitude Q;
comparing the taxonome to at least one reference taxonome;
and generating from the result of the comparison the precursor signal indicative of the onset of breakdown of the insulation degradation.

2. The method of claim 1 in which the measured data forming a dataset is obtained over a single substantially complete cycle.

3. The method of claim 1 or claim 2 which further comprises an initial step of generating the reference taxonome by obtaining at least one dataset of partial discharge data from the machine before degradation has significantly commenced.

4. The method of claim 3 in which the reference taxonome is generated by obtaining several datasets of data, forming a taxonome for the data in each dataset, and taking the mean (or some other statistical average) of the data in the taxonomes.

5. The method of any preceding claim in which the or each taxonome obtained from the measured data is compared to the reference taxonome to produce a positive and a negative error value, the two error values being compared to produce the indicator signal.

6. The method of any preceding claim in which the positive error value is indicative of the number of partial discharges in at least one class of the taxonome that exceed the number of partial discharges in the corresponding class of the reference taxonome.

7. The method of claim 6 in which the total number of partial discharges across all classes of the taxonome form the basis of the positive error value.

8. The method of any preceding claim in which the negative error value is indicative of the number of partial discharges in at least one class of the reference taxonome that exceed the number of partial discharges in the corresponding class of the measured taxonome.

9. The method of claim 8 in which the total number of partial discharges across all classes of the taxonome form the basis of the negative error value.

10. The method of any one of claims 6 to 9 in which the indicator signal is produced when the positive error value and negative error value is identical at the point in time immediately following that at which the positive values have exceeded the negative values.

11. The method of any one of claims 6 to 10 in which each error value is produced by only counting the numbers of discharges in each class that exceed (or fall below) the reference by a predetermined error margin.

12. The method of claim 11 in which the error margin differs from class to class.

13. The method of any preceding claim in which the data for each taxonome is obtained whilst the machine is on-line.

14. The method of any preceding claim in which the or each taxonome is obtained at a predetermined time interval during operation of the machine.

15. The method of any one of claims 1 to 13 in which the data forming each taxonome is obtained at a time dependent upon the operating regime of the machine.

16. The method of claim 15 which further comprises the step of obtaining more datasets when the machine is accelerating or decelerating when the machine is loaded or unloaded than when it is in a steady state.

17. The method of any preceding claim in which more than one reference taxonome is provided corresponding to different operating regimes of the machine, monitoring the operating regime of the machine and comparing the taxonomes obtained during a given regime with the respective reference taxonome for that regime.

18. A method of generating a precursor signal indicative of the onset of failure of the insulation in an electrical machine substantially as described herein with reference to and as illustrated in the accompanying drawings.

19. A monitoring apparatus for an electrical machine or component, the apparatus comprising:

sensing means located at the machine that is adapted to produce at least one output signal indicative of the amplitude of and number of partial discharges that occur in the machine;

signal receiving means located proximal to the machine that is adapted to receive the output signal from the sensing means;

storage means adapted to store the data contained in the output signal received by the signal receiving means to form a dataset comprising the total number N of partial discharges occurring over at least one substantially complete electrical cycle of the alternating voltage in the machine; and

signal processing means adapted to process the N stored data values to produce a taxonome comprising a statistical representation of the number Nc of partial discharges in the dataset as classified by their associated magnitude Q.

20. The apparatus of claim 19 which further includes a data transmission means whereby the taxonome, and optionally the raw data stored in the storage means, is transmitted to a remote supervisory system for further processing.

21. The apparatus of claim 19 or claim 20 in which the sensing means is further be adapted to produce one or more additional output signals representative of the operating conditions of the machine.

22. The apparatus of claim 19,20 or claim 21 which is adapted to produce taxonomes from the output of the sensing means at times determined by the operating regime of the machine.

23. The apparatus of claim 22 which is adapted to produce more taxonomes for one operating regime than another, for example at acceleration of the machine than during steady state operation.

24. The apparatus of any one of claims 19 to 23 that is adapted to process the stored data to produce a precursor signal that is a precursor of failure of the insulation, such as stator insulation, in the electrical machine.

25. The apparatus of claim 24 in which the precursor signal is produced in accordance with the method of any one of claims 1 to 18.

26. The apparatus of any one of claims 19 to 25 which comprises at least a first processing unit which is adapted to produce the taxonomes from the raw data and a second processing unit that is adapted to correlate the taxonomes with the data indicative of the operating conditions of the machine.

27. The apparatus of claim 26 in which the first processing unit is provided local to the machine and the second unit is provided at a remote location.

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23

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Other: Online: EPODOC, JAPIO, WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	GB 1542335	(S T C) see p.1 l.87 - p.2 l.15	-
A	WO 98/47009 A2	(G E) see p.1 ll.5-8	-
A	WO 91/19991 A	(SITELEC) see p.3 l.27 - p.4 l.4	-
A	US 5506511	(NILSSON) see col.3 l.56 - col.4 l.17 & Fig.6	-
A	JP 11352179 A	(KODENSHA) see drawings and PAJ & WPI abstracts	-

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
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